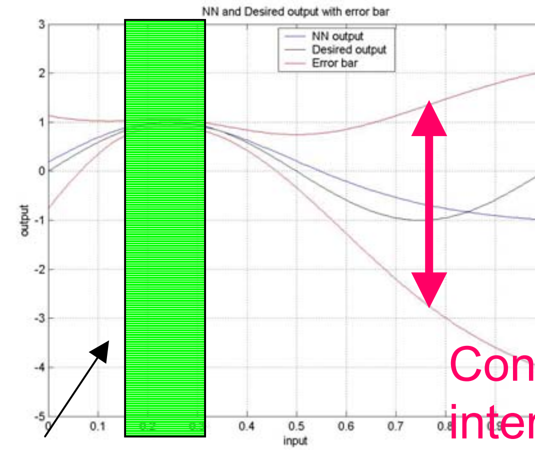
V&V of Neural Networks

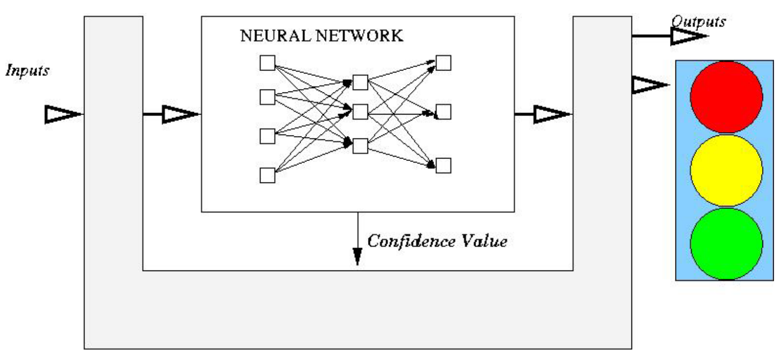
Intelligent Monitoring Harness

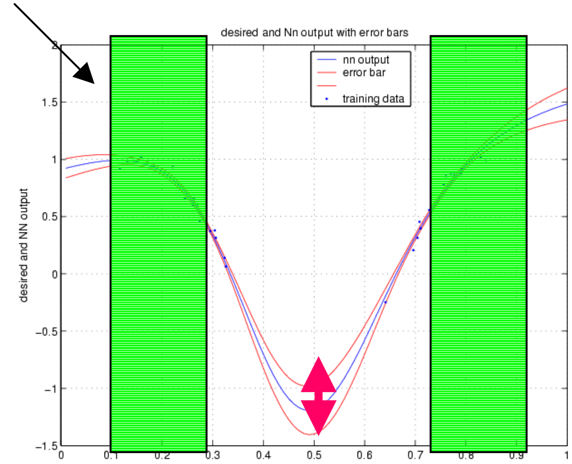


Confidence interval

"Develop methods that combine mathematical analysis and testing with dynamic monitoring to ensure robust convergence and stability. Output will be methods for pre-deployment verification, and a prototype software harness that monitors online adaptation to signal insufficient confidence in neural-net output."

Training Domain





- Calculation of *confidence interval*
- Cockpit annunciation

Explanation of Accomplishment

- **POC:** Johann Schumann (ASE group, RIACS,Code IC, schumann@email.arc.nasa.gov)
  Pramod Gupta (ASE Group, QSS, Code IC, pgupta@email.arc.nasa.gov)
- **Background:** Artificial neural networks (ANN) offer a powerful and versatile computational model for adaptive controllers. A major benefit of such a controller is an ability to adapt to unforeseen events, e.g., loss of an actuator. Feasibility of ANNs for NASA applications currently is being investigated in simulation for commercial transportation aircraft, and in flight of the F-15 active aircraft (Intelligent Flight Control System, IFCS). In all avionics applications, the percentage of flyable situations after a failure could be increased considerably. Soon-to-come NASA missions of long duration also require such controllers. During such a mission, failures are likely to occur, because the mean time between failure (MTBF) of sensitive equipment may not be much longer than the duration of the mission. Since manual repair is out of question, the system has to cope with such failures or degradation. Thus ANN based adaptive controllers will be of high importance to ensure mission success. The goal of this work is to develop methods and techniques that allow for rigorous V&V of ANN based adaptive controllers ultimately supporting their certification – a major prerequisite for most NASA applications. Our approach combines mathematical analysis, testing, and dynamic monitoring to ensure robust convergence and stability. We are developing methods for pre-deployment verification, and we are designing and implementing a prototype software harness that monitors quality of adaptation during the mission, by computation of confidence intervals.
- **Shown:** Graphs show the confidence interval (error bars) around the actual output of the neural network. It is observed that the width of the error bar depends on the local density of the input data, with the error bar increasing in magnitude in regions where no or few data points are available. Thus, this error bar reflects the ANN's confidence in handling the current situation. The monitoring harness grabs both input and output lines of the ANN and checks for low confidence or possible instability. These situations are fed into a cockpit annunciator for early warning.
- **Accomplishment:** The monitoring harness technique and initial demonstration of measuring the confidence interval of an ANN were presented to our collaborators (POC: Dale Mackall) at Dryden (DFRC) on 10/29-10/30/2002. An in-depth demonstration and discussion of the control models, developed in Simulink at Dryden, has paved the way for our goal of implementing and evaluating a prototype monitoring harness.
- **Future Plans:** Future plans include the following activities:
  - Refinements of the confidence interval algorithm
  - Prototype implementation in Simulink models and Nnet, and experiments with aircraft data
  - Support for Dryden's IFCS V&V effort
  - Work on V&V Process Guide (with Stacy Nelson)